

Integrated Design and Restoration of Ground Drainage System at DIET College

Er. N. Ramu
Assistant professor

Dadi Intitute of Engineering and Technology (A)
Dadi Intitute of Engineering and Technology,
Visakhapatnam

Y. Vasu, Sd. Zayan, A. Pavan Kumar
UG Student

Dadi Intitute of Engineering and Technology (A)
Dadi Intitute of Engineering and Technology,
Visakhapatnam

Abstract : Institutional campuses, particularly in regions of high seasonal rainfall and clayey soil conditions, require effective drainage infrastructure for the continued structural, safety-related and functional operation. Poorly designed and insufficient drainage system leads to stagnation of water which erodes the pavement, weakens foundations and affects the academic activities. The context of the current study is integrated ground level drainage design and rectification on a college campus experiencing waterlogging during monsoon every year. A comprehensive field survey was carried out to delineate low-lying area, existing drain status and catchment attributes. Storm peak discharge determined by Rational Method and the appropriate drain sizes devised for the calculated discharges. The model structure combines the surface drains, subsurface perforated PVC pipe networks, nonwoven geotextile filters, graded gravel media and groundwater recharge structures such as soak pits. Performance evaluation showed that the results were decreased the duration of water stagnation, improved runoff conveyance capacity, increased land usability and declined maintenance work. The application of sustainable drainage system elements enhanced ground water recharge and ecological improvement. This study shows that the site specific-drainage system is technically feasible, economical and transferable to other institutional campuses in clay soils prone districts with similar drainage problem.

Keywords: Ground drainage, stormwater management, campus infrastructure, clayey soil, subsurface drainage, sustainable drainageI.

INTRODUCTION

Drainage facilities are important components of the civil infrastructure for safely disposing excess surface and subsurface water from developed areas. Poor drainage is the leading problem behind the premature degradation of highways, pavements, structures and open areas. Drainage

systems – Clearly any educational establishment needs successful drainage if it is to continue operating for both academic and living purposes.

In the developing world, drainage systems are often implemented with little regard for hydrological or soil conditions leading to a high rate of failures during storms. The situation worsens in the clayed soil site associated with low-infiltration rate and high-run off potential.

Water logging in DIET Anakapalli: The Campus of Dadi Institute of Engineering & Technology at Anakapalli is facing water logging problems during the monsoon, which causes operational disturbances and damages to Infrastructure. For this purpose, herein the characterization of current drainage problems and an integrated

surface/subsurface drainage system is presented to achieve sustainably in long term.

II. LITERATURE REVIEW

One such remarkable application was reported by Aher et al. (2015) in village Anchalgaon of district Aurangabad, characterized by repeat drinking water scarcity that was primarily due to defective infiltration arising on account of a thick layer clay sandwiched between the boulders. To mitigate this problem, artificial recharge structures in the shape of recharge trench-cum-shaft systems were designed and introduced as a component of integrated groundwater management plan. Post-implementation inferences Based on the post-implementation observations it could be concluded that there was a marked improvement of groundwater from new open wells, recorded with increased water level in PWS well and improved recovery of HP discharge. This enhancement helped reduce the village's reliance on tanker-fed

water and established better sustainable drinking water supply.

An interesting case has been recently reported by Sayana and colleagues. (2010), who studied the performance artificial recharge structures in the St. Peter's Engineering College Area, Avadi, Chennai based on artificial recharging effect. The rainwater harvesting scheme (rainwater collected from roof, recharge well and percolation pond) implemented during 2004 to 2007 had contributed in recharging

III. METHODOLOGY

The methodology adopted in this study involved the following systematic steps:

Field Survey and Data Collection

- Visual inspection of existing drains
- Identification of low-lying areas
- Measurement of slopes and drain dimensions
- Mapping of catchment areas

Rainfall and Runoff Analysis

The Rational Method was used to estimate peak runoff:

$$Q = C \cdot I \cdot A$$

Where:

Q = Peak discharge (m³/s)

C = Runoff coefficient (for clayey soil: 0.6–0.8)

I = Rainfall intensity (mm/hr)

A = Catchment area (ha)

Design rainfall intensity was selected from WORLDWEATHERONLINE.

Evaluation of Existing Drainage

The score of each part the drain was evaluated for:

- Hydraulic capacity
- Structural condition
- Flow continuity
- Maintenance status

Design Criteria

The following criteria were adopted:

- Adequate hydraulic capacity
- Self-cleansing velocity
- Economic feasibility
- Ease of maintenance
- Sustainability
-

of the aquifer system in the campus. Built to trap and seep rainwater through the ground, they also helped recharge aquifers.

Groundwater level post-implementation monitoring revealed a significant rise and positive alteration in flow directions across the campus. Hydrogeological models also revealed the northern edge of the campus to be a comparatively superior recharge zone, indicating variability in recharge potential at the site scale.

IV. MATERIALS

3.1 Cement: Ordinary Portland cement of 53 grade conforming to IS: 169-1989 has been used for this investigation. The result of tests included on cement are as follow.



FIG 3.1- CEMENT

3.2 Gravel Course Sand : Gravel consists of crushed stones used as a drainage layer. It provides high permeability and prevents water stagnation.

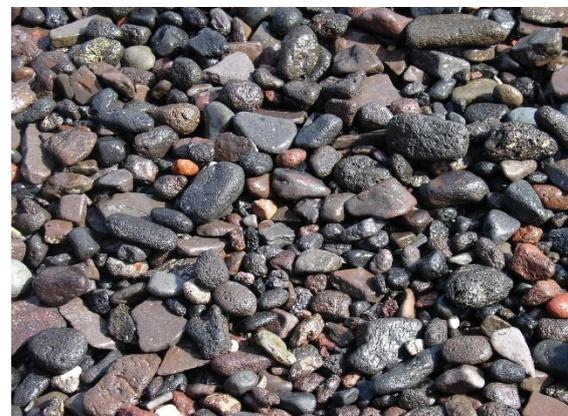


FIG 3.2 A - GRAVEL

Coarse sand is placed above gravel to act as a filtering layer. It prevents fine soil particles from

entering the gravel and pipe, thus avoiding clogging.



FIG 3.2 b- COURSE SAND

3.3 Pvc Perforated Pipes: PVC perforated pipes are lightweight plastic pipes with small holes along their surface. These holes allow water to enter the pipe and get discharged safely. They are widely used in subsurface drainage systems because they are corrosion-resistant, easy to install, durable, and cost-effective.



FIG 3.3- PVC PERFRATED PIPES

3.4 Non-Woven Geotextile : Non-woven geotextile is a synthetic fabric used in drainage systems for separation and filtration. It prevents soil from mixing with gravel while allowing water to pass through. It increases the life and efficiency of the drainage system.

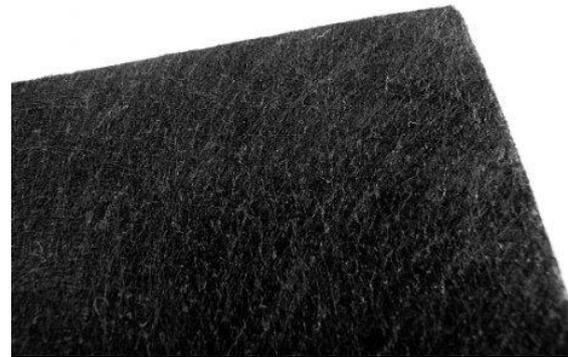


FIG 3.4- NON WOVEN GEOTEXTILE

V. EXPERIMENTAL INVESTIGATION

Constant Head Test:

| SI NO | QUANTITY (Q) CM ² | TIME, (t) seconds | Permeability K= Q/Ait Cm/s |
|-------|------------------------------|-------------------|---|
| 1 | 100 | 2830 | =100/78.5x0.84x2830 = 5.35x10 ⁻⁴ |
| 2 | 200 | 5700 | =200/78.5x0.84x5700 = 5.32x10 ⁻⁴ |
| 3 | 300 | 8490 | =300/78.5x0.84x8490 = 5.85x10 ⁻⁶ |
| 4 | 400 | 11320 | =400/78.5x0.84x11320 = 6.72x10 ⁻⁷ |

Falling Head Test :

| SL NO | Initial time t1 (Sec) | Final time tf (sec) | Initial Head h1 (cm) | Final Head h2 (cm) | $\frac{h1}{h2}$ | $\log_{10} \frac{h1}{h2}$ | $KT=C \frac{\log_{10} \frac{h1}{h2}}{tf-t1}$ |
|-------|-----------------------|---------------------|----------------------|--------------------|-----------------|---------------------------|---|
| 1 | 0 | 2264 | 95 | 75 | 1.27 | 0.1038 | = 29.24x(0.1038/2264) = 1.34x10 ⁻³ |
| 2 | 0 | 1698 | 95 | 80 | 1.187 | 0.0744 | = 29.24x(0.0744/1698) = 1.281x10 ⁻³ |
| 3 | 0 | 2830 | 95 | 70 | 1.357 | 0.1325 | = 29.24x(0.1325/2830) = 1.369x10 ⁻³ |
| 4 | 0 | 3396 | 95 | 65 | 1.461 | 0.1646 | = 29.24x(0.1646/3396) = 1.646x10 ⁻³ |

The outcome value for the above two tests is in the limits as mentioned in the IS 2720 (Part 17): 1986 – Methods of Test for Soils, Part 17: Permeability Tests.

PROPOSED INTEGRATED DRAINAGE SYSTEM

Surface Drainage Design:

Surface drains were designed along:

- Roads
- Open spaces

Rectangular and trapezoidal channels with suitable gradients and lining were recommended to facilitate the efficient conveyance of discharge.

Subsurface Drainage System

Perforated PVC pipes, wrapped in geotextile and backfilled with graded filter media for the removal of excess groundwater under water prone areas.

Sustainable Drainage Measures

The development included the following sustainable features:

- Soak pits
- Recharge trenches
- Rainwater harvesting structures
- Permeable paving in selected areas

Outfall and Disposal System

All drains discharged to a single outfall to the stormwater drain of the municipality with silt traps installed as required so as not to emit solids.

VI. RESULTS & PERFORMANCE

Performance of the integrated drainage system was tested by a comparison of pre-restoration and post-design campus conditions in terms of field observation, discharge analysis, and hydraulic efficiency. Parameters which were analyzed are time of water stagnation, surface capacity for runoff conveyance, usability and maintenance.

6.1 Reduction in Water Stagnation

Before deploying the proposed drainage system, cricket ground at DIET College was experiencing high level water stagnation during moderate to heavy rainfall events. Because clayey soil with low permeability dominated, rainwater infiltration into the soil was heavily inhibited. Consequently, such extensive soil saturation (~48–72 h post-rain event) contributed to one or more pools of water at the ground surface and thus lethargic drain. The inability to drain water for a prolonged period of time is very bad, failing the usability of the ground, obstructing campus activities and pedestrian movement, and raising the risk of property deterioration on the surface and outside buildings.

To solve the problem, surface and subsurface drainage system was designed and installed only for the identified water stagnation zone. It is composed of parallel perforated subsurface PVC pipes laid at an approximate depth of 1.1 m, all connecting with collector drain that will finally connect to surface drainage system. A small surface drain of size 0.20 m × 0.20 m along the western boundary of the ground was also provided to carry away minor localized runoff in this area.

These calculations reflect the performance of proposed drainage network. By control of drainage system, it is expected that the time for surface flooding will be decreased from 48–72 h to about 1–4 h and subsequent rainwater remained in soil pores will be drained completely within 6–8 h after rainfall with same intensity.

The aforementioned factors have all contributed to significant improvements in drainage performance.

Ground Regrading with approximately 1% crown slope to allow for natural surface runoff into the drainage network

Significant decrease in pressure head by comparison (indicating drainage) observed after installation of parallel subsurface perforated PVC pipe drains within identified stagnation zone to intercept groundwater trapped.

So, that would include: Installing a collector drain system to transport the collected subsurface flow in an efficient manner towards the discharge point.

Localized surface drain (0.20 m × 0.20 m) along the western limit for removal of shallow surface runoff and localized ponding prevention

Inherent clogging prevention by the use of gravel/courser sand (filter media layers, hence improved water movement into the subsurface pipe).

Complete integrated drainage system: Integrating field and subsurface water drainage that allows for hydraulic coupling of the surface layer to enhance the efficiency of the ground drainage network by speeding up the discharge of excess water. This also decreases the evaporation stagnation time, which leads to further stabilization of the ground, improved usability of the sports field itself and minimizes damage due to structural deterioration as well as pavement during rainfall events.

6.2 Increase in the Runoff Transmitting Capacity

Hydrological assessment of the existing drainage system revealed that the earlier drainage structure on DIET College cricket ground failed to cope with storm water runoff during precipitation events. They explain that the lack of a systematic drainage network, in addition to soil permeability due to clay soils, led to slow surface runoff movement and prolonged water accumulation on the ground surface. Also, incomplete construction of existing

drainage channels and inability to maintain the desired slope created stagnant pockets that extended rainwater removal during monsoons.

In this study, hydrological analysis was performed using the Rational Method to calculate peak runoff from the defined catchment area. Assuming a runoff coefficient (C) of 0.6, rainfall intensity (I) of 75 mm/hr, and a catchment area (A) of 2441.56 m² on the peak discharge from the study area was found to be approximately equal to 3.05 m³/s.

Rather than large surface drains, the proposed design includes subsurface perforated PVC pipe drains, a collector and local surface drainage—an integrated approach to drainage comprising both in-situ natural remediation as part of the site. A subsurface drainage system comprising parallel perforated PVC pipes is installed in the recognized water stagnation zone at an approximate depth of 1.1 m below ground level. This pipe is wrapped with graded media layers of gravel and coarse sand, so the water can splash into the pipes and there will be no more clogs. The lateral subsurface drains converge to a collector drain to transport the collected groundwater and infiltrated runoff to the outlet.

Along with this subsurface drainage network, a minor surface drain of size 0.20 m × 0.20 m has been constructed along the western boundary of the ground. Minor, localized surface runoff expected along that section of the site gets channeled to this drain and from there to the collector drain system. As the water collection in such area is too low, it is assumed that drainage of smaller size would ensure local runoff removal and there is no need for large structural drains.

This is due to a combined sequence of action of the subsurface drainage pipes with the collector drain and localized surface drainage mechanism, thereby significantly increasing the runoff conveyance area in ground. In this manner; the subsurface system stops the water that has penetrated the soil layers, and the collector drain transports it safely to receive. Thus, the water from rain storms can efficiently be drained off the surface of ground and subgrade layers.

In conclusion, the better drainage design will contribute to improve hydraulic efficiency of ground drainage system and find an impact on monsoon rainfall conditions resilience in campus infrastructure. The described system minimizes

water logging and allows for quick drainage of excess water, ensuring the cricket ground remains fit for use in the long run

Post-design evaluation showed:

- Smooth flow conditions without overtopping.
- No return in the vicinity of outlet openings.
- The need to always stay cleaner increasing self-cleansing velocity and decreasing sedimentation.
- The efficiency of the drainage network was increased significantly by means of uniform channel lining, optimized cross-sections and improved outlet connection.

6.3 Enhancement of Surface Usability

Prior to restoration, internal roads, parking lots and footways repeatedly had rendered slippery; making them unsafe after each rain during shower when it was not possible to walk or drive over there. These conditions made academic procedures out of hand and allowed for accidents.

Following the integrated drainage implementation:

- Roads remained motorable during rainfall
- Sidewalks were not allowed to hold standing water for extended period.
- The playground and the open spaces dried more quickly.
- There was better access to campus for both foot and vehicular traffic.
- The gross functional utility of the campus infrastructure was clearly enhanced, particularly in heavy monsoon seasons.

VII. CONCLUSION

This study aimed to investigate and solve the chronic rainwater stagnation problem in the vicinity of DIET College cricket ground. SITES INVESTIGATIONS THROUGH FIELD OBSERVATION OF RAINFALL DATA, SOIL PERMEABILITY AND HYDRULIC TESTINGS To understand drainage characterization and develop the best solution for drainage system, detailed site investigations were conducted including field observations, rainfall data analysis as well as soil permeability tests.

Utilising the Rational Method for hydrological investigation, approximately 2441.56 m² of catchment could produce peak runoff of roughly 3.05 m³/s in heavy rainfall situations depending on the runoff factor (0.6) and rainfall intensity (75

mm/hr). The analysis confirmed that poor drainage conditions and slow runoff movement were leading to prolonged water stagnation in the ground.

Soil investigation values for falling head permeability mean that the coefficient of permeability was estimated to be 1.4×10^{-5} m/s, which meant that the soil consisted mainly of clayey materials that were also low-permeable. The low permeability of soil means that rainwater is infiltrated slowly and water accumulates in the soil and surface water remains stagnant for a long time.

In order to overcome this problem, an integrated drainage system consisting of sub-surface perforated PVC pipe drains was proposed to be implemented in the stagnation zone identified. Similar to transport, 150 mm diameter pipes were laid at a depth of 1.1 m below ground and spaced out approximately every 10 m with the other end connected to a collector drain removing collected water through outlet. Filter media layers of gravel and coarse sand surround the subsurface pipes to facilitate movement of water through them while preventing their clogging.

A local surface drain with a dimension of 0.20 m \times 0.20 m was also provided parallel to the western boundary of the ground, which helps in draining out minor surface runoff that occurs within this part of the site. Moreover, a nominal 1% crown slope for ground regrading was included to induce natural flow towards drainage system.

The hydrological performance evaluation report of the proposed drainage system indicated that water stagnation over the ground surface area after a major storm event can be reduced from 48–72 hours with no facility to 6–8 hours for similar intensity events. This allows for further enhancement of the general drainage capacity of the site as well as draining surface and sub-surface layers in a shorter time.

Thus, the design of an integrated surface and subsurface drainage approach shall prove to be a valid and sustainable method that will mitigate water stagnation in institutional campuses with clayey soil with poor natural drainageability.

VIII. REFERENCES

- [1] **Bureau of Indian Standards (BIS)**, *IS 1742:1983 – Code of Practice for Building Drainage*, New Delhi, India.
- [2] **CPHEEO**, *Manual on Sewerage and Sewage Treatment Systems*, Ministry of Housing and Urban Affairs, Government of India, New Delhi, 2013.

- [3] **K. Subramanya**, *Engineering Hydrology*, 4th Edition, Tata McGraw Hill Education, New Delhi, 2013.
- [4] **S. C. Rangwala**, *Water Supply and Sanitary Engineering*, Charotar Publishing House Pvt. Ltd., Anand, Gujarat, 2012.
- [5] **Indian Roads Congress (IRC)**, *IRC SP: 50-2013 – Guidelines on Urban Drainage*, New Delhi, India.
- [6] **Arora, K. R.**, *Irrigation, Water Power and Water Resources Engineering*, Standard Publishers Distributors, New Delhi, 2011.
- [7] **Punmia, B. C., Jain, A. K., and Jain, A. K.**, *Environmental Engineering – Volume I: Water Supply Engineering*, Laxmi Publications, New Delhi, 2009.
- [8] **Patel, R., Sharma, D., and Singh, V.**, “Performance Evaluation of Subsurface Drainage Systems in Clayey Soil Conditions,” *International Journal of Engineering Research & Technology (IJERT)*, Vol. 8, Issue 5, 2019.